1.6 Data Exchange Standards for Construction Automation

Kent Reed
Building and Fire Research Laboratory, NIST

My computer integrated construction group was created some ten years ago to address data exchange standards and other issues related to helping the construction industry apply computing and, in particular, to help the construction industry integrate its use of computers.

Most of the work that our group has done in the past has been related to what happens in the AE offices, what happens with regulatory authorities, what happens in manufacturing and fabrication. Introducing the construction site adds new features that we have not addressed directly although we've always said we're dealing with the product life cycle which would include construction and include operation. Most of the work, to date, has been in the fun end of characterization of the construction project. The problem is that we deal with a lot of data streams. Lets let this one computer be the exemplar for all the computers in the AE office, some in the construction shack, some on automated equipment. So there are a variety of data streams. How do you integrate this system so that you get beyond having one computer for each task and human beings laboriously translating between computers or inferring the meaning of the data? It happens that work that's been going on in the past has addressed project design data; it has addressed vendor product data, but not most of the other streams which we're talking about here: for example, getting static site data from GIS systems into this manage. Getting real time site data from the kinds of measurement equipment Bill was talking about and Eric talked about, control data back out; those are new features we have to address as part of this initiative.

Being a loyal member of the National Institute of Standards and Technology, of course I think standards are the way to pull this off. In fact, there are strong arguments for consensus standards being the way to integrating information technology systems — and I won't go through all of the arguments for them now.

Certainly one particular objective is, you'd like to get the information out of the application software. Systems in the past tend to integrate by pushing lots of applications together through custom interfaces and your data had meaning only in the context of those applications. We're trying to develop neutral data exchange standards where the data can be captured and can be reused and can be understood outside the context of the specific application. Something we have to address very carefully in this initiative is how do we handle the incremental introduction of automation. Clearly we're not going to satisfactorily integrate everything on the site all at once, it just

isn't going to happen. So standards which require that, aren't going to make it to the marketplace, in my opinion.

The kinds of trends we see in information technology standards are both good news/ bad news kinds of stories. First of all, in the last ten years, data exchange standards have moved more toward semantics-based exchange rather than simple data structures. The good news is it makes it easy to understand the information streams that you have without the resource applications that generated it. The bad news is that you have to participate in the definition because its your semantics you're trying to capture. It's not something that some computer jock back in the software house is likely to be able to do by his or herself.

Another trend is pluralism, we have recognized that there's no such thing as the one-size-fits-all standard. The fact that in information technology more and more we see many different standards emerging and being carbonized. The good news is, you kind of get to mix and match standards that fit your problem. The bad news is that carbonization takes a lot of work. You actually see that technology changes faster, accounting for the harmonization of standards slowing down. We're trying to figure out ways to improve on that set when in fact other parts of NIST are directly addressing how to speed up the creation of new standards.

Another trend that I find very helpful is that all of these standards are moving towards open systems environments. I'll try not to define open systems very carefully, but in effect that it allows them to plug and play with different application software packages, more-or-less without recourse to the harbor platform. Often without recourse to the operating system as well. Those trends are very good news for us in the construction industry, precisely because we are such a dispersed group of actors. We deal with descriptive and heterogeneous systems and that's just not going to change.

A quote that you often see floating around the standards community is, "the wonderful thing about standards is there are so many of them." That is particularly true in information technology in core streams, ranging from almost proprietary standards to the best and most widely distributed national standards. We've got this alphabet soup of standards -- all of which may apply in some way to our problem -- from the drawing exchange format for AutoCAD, Microsoft's Object Linking Embedding environment (which is still kind of a now you see it now you don't standard), RSA which is the leading industrial method for encrypting and authenticating data etc. Industry standards that have not been developed by single vendors are in some sense more accessible. National standards are generally maintained by consensus standard bodies in the U.S. IGES, or ANSI interchange format, are examples of such standards. And the various international standards. The trick is to figure out where to position yourself along all this mess as we deal with particular parts of the problem. I'd like to talk about just one of those. Bill's put me into a session called "State-of-the-Art". I won't quibble about that. Sort of generically the NIST approach in all these standards is : "let's try to work with industry to find out

what the requirements really are for a standard and help develop technical solutions that meet those requirements." Typically, we develop within NIST experimental standards and/or reference implementations that help best reach the solution. We work with the appropriate standard bodies to produce the resulting standards.

One of the features of NIST is its continuity. It has staying power in activities that would cause people's eyes to glaze over. Most company's say we really cannot afford to keep going back to more meetings. But in effect, by working through this, we can be an effective voice for industry within the standards body, and then try to close the loop working with industry to implement those standards. To make sure they actually work, provide interoperability. That's kind of a general mesh that lays over a lot of our work, whether it's my group or groups in other laboratories.

The specific standard I want to talk about, because I think it plays a key role in this initiative, is informally known as STEP — Standard for the Exchange of Product Model data. It's an ISO standard, and it's one in which there is considerable U.S. effort, in fact, probably more than 50% of the labor has come from the U.S., including a lot from NIST. It is just now starting to emerge. The first parts were approved as an international standard this last year. Fifteen industrialized countries voted to endorse it, including the U.S. And NIST worked with other technology based organizations to develop the core concepts.

My group has spent a good deal of time working with U.S. industry to try to understand what the AEC requirements, from the perspective of the construction industry, are with respective to this stuff. I'd like to say that all parts of the construction industry have been equally represented, but it is really not true. Most of the responses we've gotten have been from the ship building industry, which thinks of itself as kind of an AEC industry. They also deal with large scale, one-of-a-kind projects. I often talk of the ship as being a building that broke away from its mooring. Maybe I should talk about buildings as ships that ran the pier. But we have had substantial interaction with the ship builders over the last five years to define these solutions that deal with piping systems and ship structures and so forth. We've had considerable luck in the last few years dealing with what we call the process plant industry — owners and operators, engineering and construction companies, fabricators, and suppliers and vendors. We are trying to define what STEP has to do in the near term to satisfy their requirements. We've been working with the international community to develop technical solutions that meet those requirements.

Let me say a word about how we have been working with industry, particularly with the process plant industry. We have been successful with getting U.S. industry to create a consortium, called Plant-STEP, Inc., for processing industries. It includes plant owners and operators, includes engineering and construction companies, suppliers and IT vendors. We are formally related to this organization through a CRDA, which lays out what we bring to the table. It's

really a response to work that's already going on in Europe. In particular, in the United Kingdom there has been a strong effort over the last few years to develop interesting stuff from the process industry perspective. Through European union funding and the ESPRIT program, the European Special Projects for Research and Information Technology that has been working with databases that support process plant engineering, and some other activities including one that is rather substantial in the Netherlands.

Japan has recently come on line with two efforts, which have been very supportive of the U.S. efforts by the way. It is surprising that the Japanese and the U.S. efforts are more in alignment and both of us seem to be somewhat in conflict with the Europeans... a rather different state of affairs than we've seen in the past. There are some other activities in the U.S. — there is the process data exchange institute from the American Institute of Chemical Engineers. It's possible that the Petrotechnical Implement Software Corporation will participate in STEP, although we are still working that out.

Well. Why should we care? Those activities European, Japanese, and the U.S., have collectively tried to carve up the universe into the life cycles of a process plant. There's has been an activity model that has been defined and agreed to internationally, and I have grossly simplified that activity model. Its really not intended to deal only with new construction, but you might assume that for the idea of starting with process design. That might just as well be, you have a model of an existing plant, what do you do to re-engineer it to bring on a new specialty chemical stream, or what do you do to introduce a new power cycle?

Process Data Exchange Institute is focusing on parts of the process engineering work. The European activities have tended to focus on information that would back up the creation of what we can a P&ID process and instrumentation diagram. The U.S. activity is focused more or less on the 3D modeling and associative attribute data.

To break out a little bit about what Plant STEP is concerned about, it has grossly divided up its world of information across different systems like piping systems, and process equipment, structural systems and so forth, and has done a gross break out of the types of data that are associated with each of those. Product ID goes across the board. The same questions as were shown in Bill's slides concerning product ID of an object on the site, we now are dealing with it in the design phase.

The issue then, from my perspective, is, assuming that STEP is the primary data exchange standard for describing the project as designed, and the primary standard for describing products as required, that is fabricated parts — steel members etc. — what else needs to be done? Well certainly, STEP needs to have as part of this initiative either bits filled in or additions added on to it that deal with more construction phase information than is presently shown. There are other systems for which there is no provision for this type of data, and even in the case of piping systems, which has the most details, there is precious little there in

terms of how would you sequence the installation of a piping system. For example, how would you take a large reactor vessel and drop it in place? What is the rigging involved in doing that? What kinds of cranes are required?

There is a companion standard, ISO 13584 Parts library, which needs to be applied to the construction products business. This is not nearly as far along as STEP itself, but in principle in the future your steel fabricator will supply all his catalog data in the format of this particular standard. But we don't know for sure it really works with construction products.

Bill's already alluded to the notion of models of construction equipment and construction equipment operations. We do not yet have a framework established for that, nor for the kinds of models we have been discussing. It is conceivable that the data for these would be exchanged using STEP, but it is just as conceivable — because software technology is a moving target — that by the time we want to standardize on this. It's conceivable that we'll use STEP for defining the static parts of that and maybe using something like the system object model from IBM as the way of defining the methods. There is a good deal of work yet to be done experimentally to see what really works and what doesn't really work in a construction-related scenario. And that may mean identifying and incorporating other standards that we may need.

Clearly, something that has to be answered fairly soon in our program is: what do we do first. We can't possibly model the whole world. What things do we need to focus on, first. That is why we are looking to close interaction with industry to help calibrate what we are doing.

Questions:

Chuck Schaidle, Caterpillar: *What do you see happening with standards for the earthwork design of the site? Topography modeling etc. Do you see STEP getting into that?*

Kent Reed, NIST: In the Plant STEP defined model, there is a primitive terrain model element. It basically says there is a collection of xyz data. And from that, many things could be derived within a particular system. But that is about as far as it has been elaborated. There is no sense in that model yet as to whether this is the undisturbed site or is that after the first cut, after the second cut, as the site is manipulated to create the plant. Even in that model, there needs to be more thought given to how to categorize the data.

Chuck Schaidle, Caterpillar: *Is there anything outside of STEP that is further along in setting standards for digital terrain?*

Kent Reed, NIST: I haven't kept up with that. There was a time when I was the chair of the AEC committee when I tried to stay tuned to the digital terrain folks, the digital cartographic folks and some other activities. My sense is that there is a lot of competition as to who thinks what best approach ought to be taken. It really hasn't been tested on an open forum to my knowledge. I don't think its an insoluble problem. Right now we

are being offered this cacophony of solutions.

Bob King, CSM: *Does STEP incorporate a standard format for transferring surface information on 3D solids?*

Kent Reed, NIST: In the interest of both compressing time and not glazing your eyes over, yes. STEP has incorporated in it some key base models including a variety of geometry models, topology, configuration management, but the way STEP is constructed you never exchange those things raw. What you exchange is an interpretation of the model in its context. It has a fully surfaced geometry model available, but you would first define what your requirements are for that, what is it you are going to send as a surface model? That's simply one representation of data about something. It may be terrain, it may be the exterior of your vessel, might be something else entirely, but unlike IGES, DXF, and the standards of the last decade you will never be in the situation with STEP where you are simply going to send some geometry and the receiving system tries to figure out what is the meaning of that geometry. That was defined before you sent it.

Chuck Schaidle, Caterpillar: *Are any of the software manufacturers that do 3D solids, kinematic modeling that we have been talking about, like Symmetrics, Deneb, any of those people, are they working with this group?*

Kent Reed, NIST: I'm not really competent to say who's solidly involved that knows a lot about kinematic modeling. There is a kinematics interest group that has not been very active recently. The CAD vendors that represent the bulk of the process industry, for 90% of all the CAD seats being used to design plants, those were represented at the table. But again this issue coming into the construction site, dealing with dynamic as well as static data is one we have to address here. Even if there is kinematic work going on at STEP, the likelihood is that at best it addresses the needs of the piece part manufacturers and part assembly drawings, not really the construction site.

John Schlecht, Iron Working Institute: *It seems to me that this maximum re-use of information, that we are almost there in some parts. Like you said, where to start? If you think of a steel building, at the time it is being designed if we had the data input that would give the fabricators that are bidding on that job they could all use data that would tell them the number of pieces, the way to connect them. So lets say 10 fabricators are bidding on the job, you wouldn't have 10 people doing the same thing, taking it off to bid. OK. So there you would be re-using that information when you do a take off from it. Then the fabricator that gets the job, the winner, the low bidder, the next thing he does, he has somebody sit down who clerically has a bill of materials, and he orders it from the mill. That would be an overlap. The information in the design could be used in the fabricating shop for cutting, drilling, and punching, and for the size of the members., for which the standard is the rolling mill. And the next step would be that that data would also provide the erection drawing or placing directions. So if you visualize a logic path, it seems to me that if the data is input in the design phase it should be able to be re-used over and over again, almost to the point where the remaining thing would be the 3D — to see in real time, where is the member being set compared to the erection plan, in*

real time in 3D. So, it seems to me we can do this, and there would be a tremendous enhancement for cost in construction.

Kent Reed, NIST: I agree with you 100%. I think the construction industry is a little bit behind. In the case of the ship builders that is precisely the scenario they have thrown up as the reason for developing the STEP application protocol. So the Navy can pass a preliminary design through a design yard, a design yard can detail that, pass it to a construction yard, and the construction yard build a ship of that class and pass the as-built data on to the logistics guys who support the ships in the fleet. That is precisely their point of view.

Bob McClelland, Fluor-Daniel *Seems to me that that technology is already available in the form of the PDS. If you take a PDS model and transmit that to the vendors, they can use the tabular data within PDS to take off any sort of information.*

Kent Reed, NIST: And is it available in several different third party vendors that build on top of AutoCAD, and its available... I can name a number of CAD systems, but try to take it out of the PDS system and put it into the third party vendor software from AutoCAD. Or vice versa. You start getting into troubles.

Bob McClelland, Fluor-Daniel: *It means that everyone's got to use a system that is compatible with each other.*

Kent Reed, NIST: And the point of trying to develop a standard like STEP is to reduce the number of times when you have to use the same system as your partner. Or at least a fully compatible system. If you cannot do it directly, then you cannot do it through a standard either. That is one of the principles that the standards writers sometimes forget. You can't create a solution that can't be done technically. If they can, then standardize the solution so that it is more accessible.